Defense Information Systems Agency

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Improving Tactical Networks for Tactical Edge Services

(EE211)

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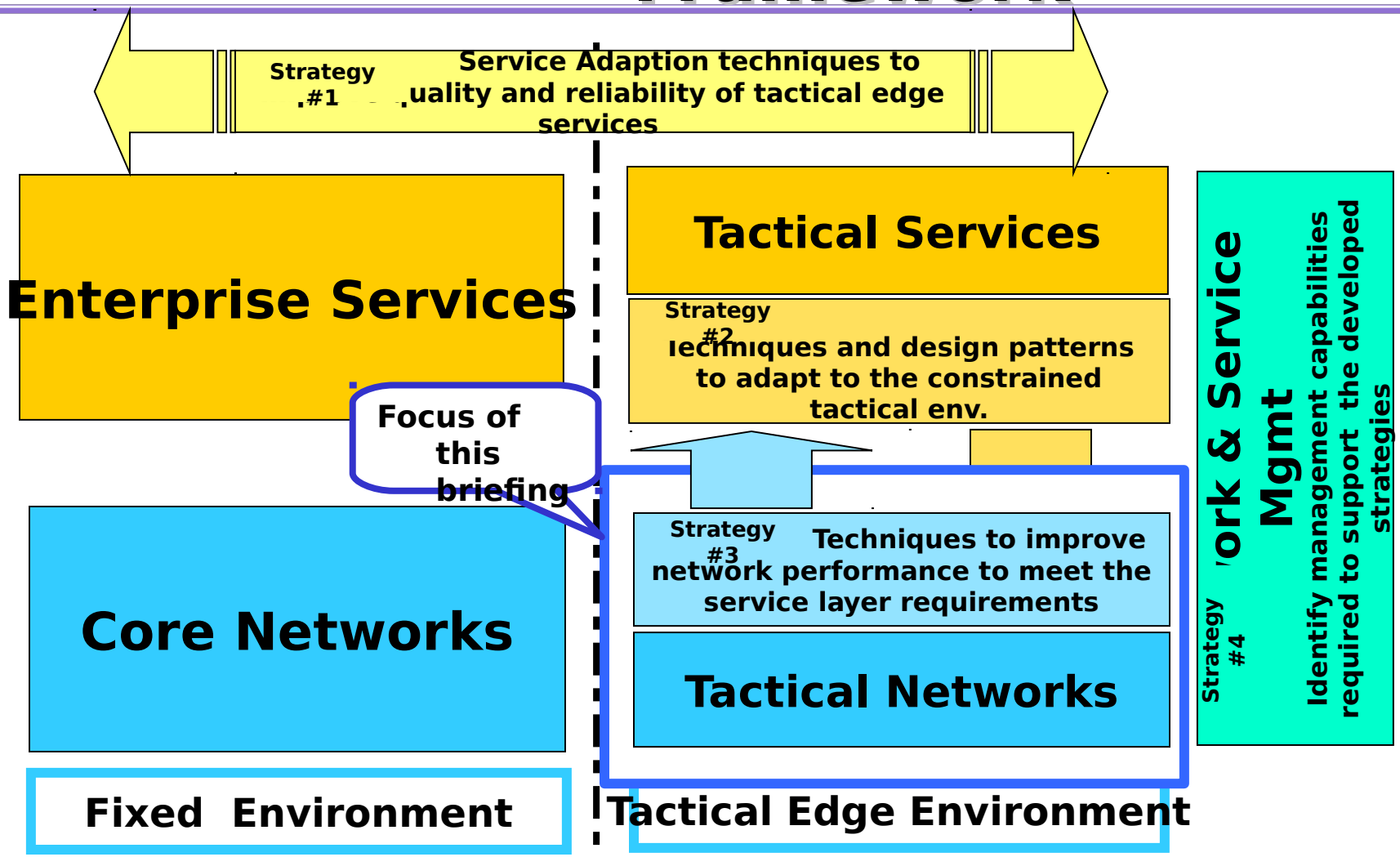
Outline

- Describe Principles of Technical Approach
- Identify Design Techniques Overcoming Tactical Edge Constraints
- Show Some Problem Solutions
- Summarize Findings and Results
- EWSE Activities

Technical Approach Framework


Strategy .#1
Service Adaption techniques to uality and reliability of tactical edge services
Enterprise Services
Tactical Services
Strategy #2
Techniques and design patterns to adapt to the constrained tactical env.
Focus of this briefing
Strategy #3
Techniques to improve network performance to meet the service layer requirements
Core Networks
Tactical Networks
Strategy #4
ork & Service Mgmt
Identify management capabilities required to support the developed strategies
Fixed Environment
Tactical Edge Environment

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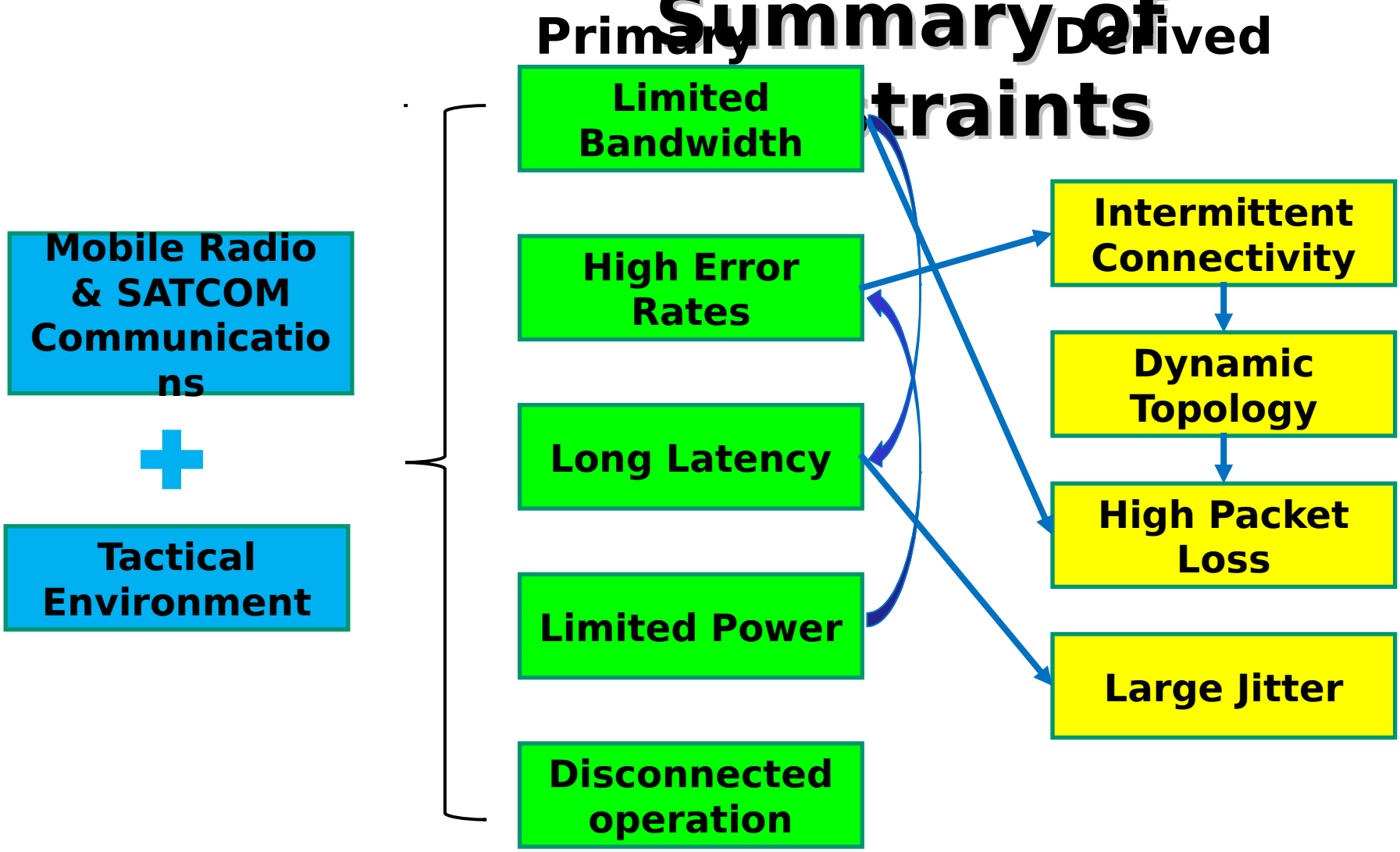
Tactical Communications Summary of Constraints



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Causes of Tactical Communications Constraints

- A constraint can be from multiple causes
- Multiple constraints can be attributed to a single cause

		Constraints								
		Disconnected operation	High error rates	Intermittent connectivity	Limited bandwidth	Limited power	Long latency	Dynamic topology	High packet loss	Large jitter
Causes	Tactical environment	X		X						
	Low SNR		X	X	X					
	Limited spectrum				X					
	ery supply		X			X				
	COM		X				X			X
	Congestion						X		X	X
	Large hop count						X			X
	Mobility	X	X	X				X		
	Packet drop								X	

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Principles of Technical Approach

- Improve RF link quality and reliability
- Provide disruption/disconnection tolerant network capability
- Provide differentiated QoS services
- Use delay and loss friendly communication protocols
- Reduce protocol bandwidth requirements
- Increase bandwidth and speed of the network

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Techniques for Design Principle – Improve RF Link Quality and Reliability

- **Improve link quality**
  - **Improve SNR**
    - **Increase transmit power**
  - **Improve link performance**
    - **Adaptive modulation and coding**
- **Improve link reliability**
  - **Time diversity**
    - **Interleaving and FEC**
  - **Frequency diversity**
    - **Orthogonal Frequency Division Multiplexing (OFDM)**
  - **Spatial diversity**
    - **Multiple antennas, Multiple-Input and Multiple-Output (MIMO)**

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Techniques for Design Principle – Provide Disruption/disconnection Tolerance Network Capability

- **Use Delay Tolerant Networking (DTN)**
  - **Use store and forward message delivery**
    - **Store a message in a node until it can be reliably delivered to the next node**
- **Use flooding for reliable message delivery**
- **Use Mobile Ad Hoc Network (MANET) technologies**
  - **Self-forming and self-healing network**
  - **No infrastructure**
  - **Each node performs routing and forwarding**
  - **Dynamic network topology**
  - **Frequent routing updates**

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Techniques for Design Principle – Provide Differentiated QoS Services

- **Implement Quality of Service (QoS) in a capacity/bandwidth limited network**
  - **Use GIG DiffServ-based QoS architecture to provide different service to high precedence traffic**
    - **Differentiated service (DiffServ) functions**
      - **Marking**
      - **Conditioning**
      - **Classification**
      - **Queueing**
      - **Scheduling**
    - **Use strict priority queueing for highly loaded tactical environment**
  - **Ensures different levels of performance to different class of traffic**

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Techniques for Design Principle – Use Delay and Loss Friendly Communication Protocols

- **Use extensions to TCP – Space Communications Protocol Specifications (SCPS)-TP**
- **Use delay mitigation methods for TCP**
  - **Reduce effects of long delays**
    - **Reduce acknowledgement delays**
      - **Use Performance Enhancing Proxy (PEP) to acknowledge packets locally**
    - **Keep SATCOM transmission busy without waiting for acknowledgement**
      - **User larger window size (TCP window scaling)**
- **Use TCP selective acknowledgements (SACKs) (RFC 2018) for packet loss**
    - **Receiver informs sender about all segments that are successfully received.**
    - **Sender fast retransmits only the missing data segments**

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Techniques for Design Principle – Reduce Protocol Bandwidth Requirements

- **Use compression**
  - **Data/payload compression**
    - **Voice, video, image, and data compression**
      - **G.729A, G.723.1, MPEG-1, JPEG, DEFLATE, Zlib, Gzip, HTTP compression, binary XML**
  - **Protocol header compression**
    - **IP/UDP/RTP Robust Header Compression (ROHC) (RFCs 4995 and 5225)**
- **Multiplex multiple payloads within a single packet**
  - **VoIP multiplexing**
    - **Combine multiple voice payloads in a single packet to save IP and UDP header overhead**
      - **NET VX series and Dialogic I-Gate**

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Techniques for Design Principle – Reduce Protocol Bandwidth Requirements

- **Increase transmission efficiency**
  - **Implement silence suppression using Voice Activity Detection (VAD). Up to 50% traffic reduction**
  - **Use multicast for point-to-multipoint communications**
  - **Transmit RF messages simultaneously without interference**
- **Improve network design and configuration**
  - **Optimize network configuration**
    - **TCP keepalive timer interval**
    - **OSPF hello timer interval**

Techniques for Design Principle – Increase Bandwidth and Speed

- **Leverage emerging high-speed commercial wireless communications systems**
  - **E.g., WiMAX (Worldwide Interoperability for Microwave Access), Long Term Evolution (LTE)**
- **Selectively deploy new tactical radio systems**
  - **E.g., Joint Tactical Radio System (JTRS) Soldier Radio Waveform (SRW) and Wideband Networking Waveform (WNW)**

Mapping Tactical Communication Design Techniques to Constraints

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- **Multiple design techniques in OSI layers**
- **A constraint can be addressed by multiple techniques**
- **A technique can apply to multiple constraints**

Design Techniques	OSI Layer	Constraints								
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Data/header compression	Many			x		x	x			x
Silence suppression using Voice Activity Detection (VAD)	Application			x		x	x			x
Reduce bandwidth requirements with voice CODECs (G.729 and G.723.1)				x		x	x			x
Store and forward Delay Tolerant Networking (DTN)	Transport	x	x			x				
TCP local acknowledgement spoofing						x				
TCP increase window size						x				
TCP Selective Acknowledgement (SACK)				x					x	
Use connectionless protocol (UDP) instead of connection oriented (TCP)			x						x	x
Increase transmission efficiency (multicast)	Network			x		x	x			x
Increase transmission efficiency (packet/payload multiplexing)				x		x	x			x
QoS				x		x	x			x
Routing with flooding			x					x		
MANET			x					x		
Automatic Repeat ReQuest (ARQ)	Data Link								x	x
MAC				x						x
Spread spectrum (frequency hopping)	Physical								x	
Spread spectrum (CDMA)									x	
Reduce fading and multipath (time diversity)									x	
Reduce fading and multipath (interleaving)									x	
Reduce fading and multipath (FEC)									x	
Reduce fading and multipath (frequency diversity)									x	
Reduce fading and multipath (OFDM)									x	
Reduce fading and multipath (spatial diversity)									x	
Reduce fading and multipath (MIMO)									x	
Improve SNR (higher transmit power)									x	
Improve SNR (higher gain xmt and rcv antennas)									x	
Improve SNR (greater antenna heights)									x	
Adaptive modulation and coding				x					x	

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Design Example : Link not Performing Optimally

- **Problem Description**
  - **Link is not performing optimally because the system is not adapting to the RF environmental changes**
- **What Caused the Problem**
  - **The link is not adapting to changes in received SNR**
- **Mitigation Techniques**
  - **Use Adaptive Modulation and Coding (AMC) to adjust the transmit parameters according to the current received SNR**

Design Example : Link not Performing Optimally

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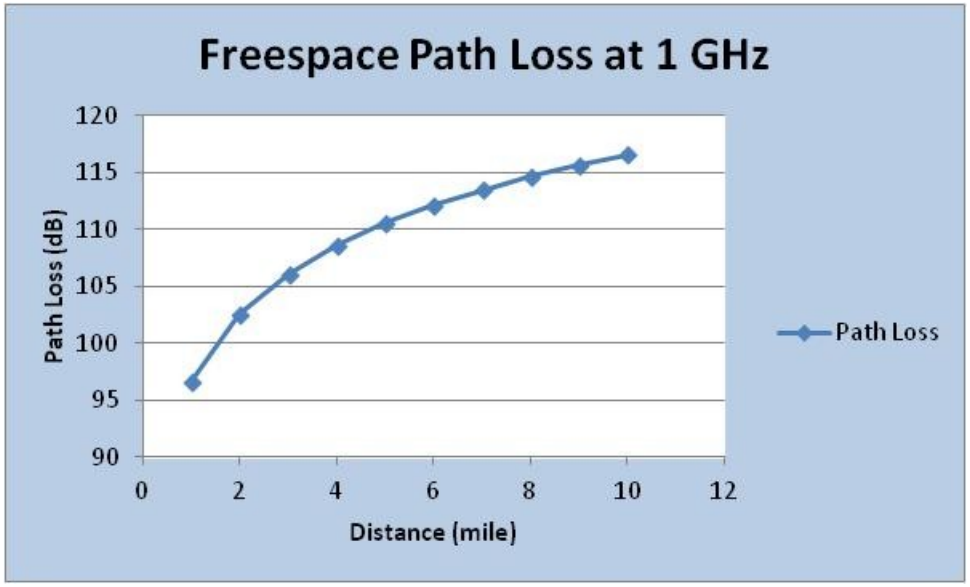
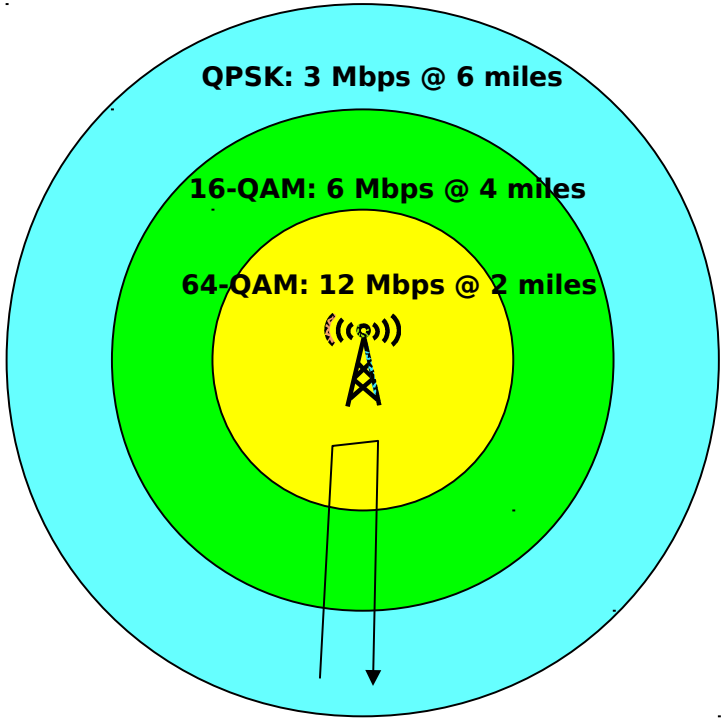
- **Use Adaptive Modulation and Coding (AMC) to achieve the highest data rate at an acceptable error rate**





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Design Example : Support Communications in Disconnected Mode

- **Problem Description**
  - **Regular messaging will fail in an intermittent and disconnected environment**
- **What Caused the Problem**
  - **Weather, jamming, mobility, tactical operations**
- **Mitigation Techniques**
  - **Use store and forward technique to store and forward the messages when the next communications opportunity becomes available by adding a disruption/delay tolerant layer**

Design Example : Support Communications in Disconnected Mode

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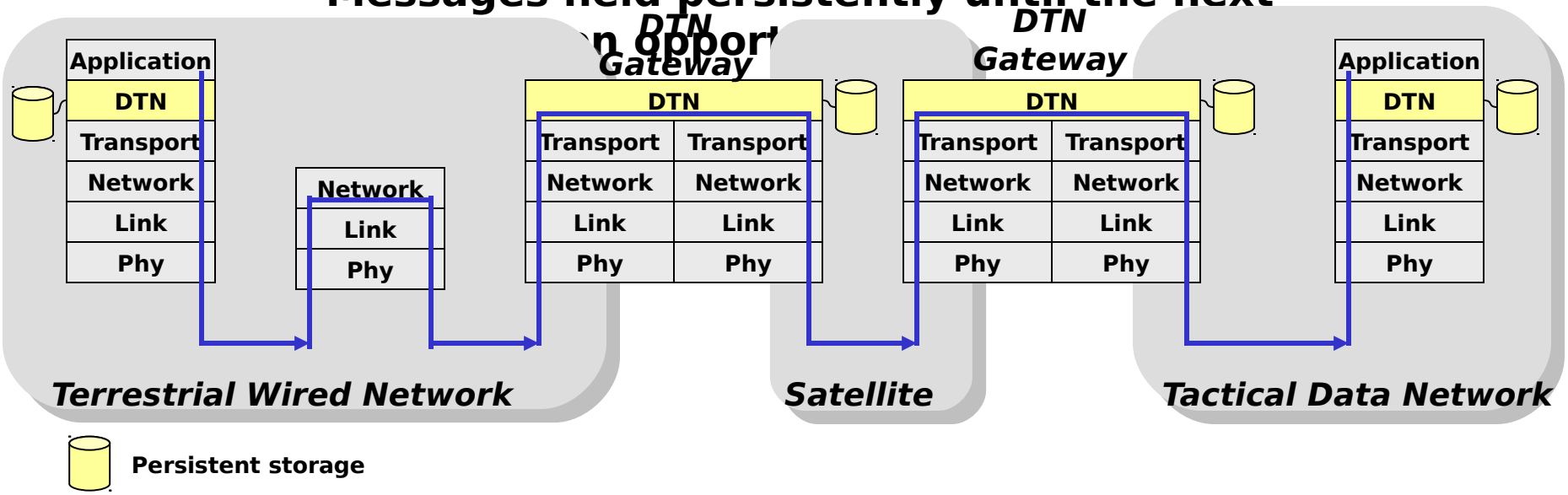
- **Use Delay Tolerant Networking (DTN)**
  - **Use store and forward paradigm**
  - **DTN interconnects disparate networking regions**
    - **Operates above traditional transport layer in OSI protocol stack**
    - **Forward when the opportunity is available**
    - **Messages held persistently until the next**



*Slide credit: MITRE Durst

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Design Example : Poor Voice Quality Problem

- **Problem Description**
  - **Poor voice quality due to dropped packets, long delays, and large jitter in tactical environment.**
- **What Caused the Problem**
  - **Dropped packets could be caused by congestion and high error rate. Long delays could be caused by voice coding/decoding, long propagation delays, queueing delays, and large hop count. Large jitter could be caused by multiple access schemes, different paths, queueing delays, and large hop count.**
- **Mitigation Techniques**
  - **Use Differentiated Services (DiffServ) technique to provide higher priority service**

Design Example: Poor Voice Quality Problem

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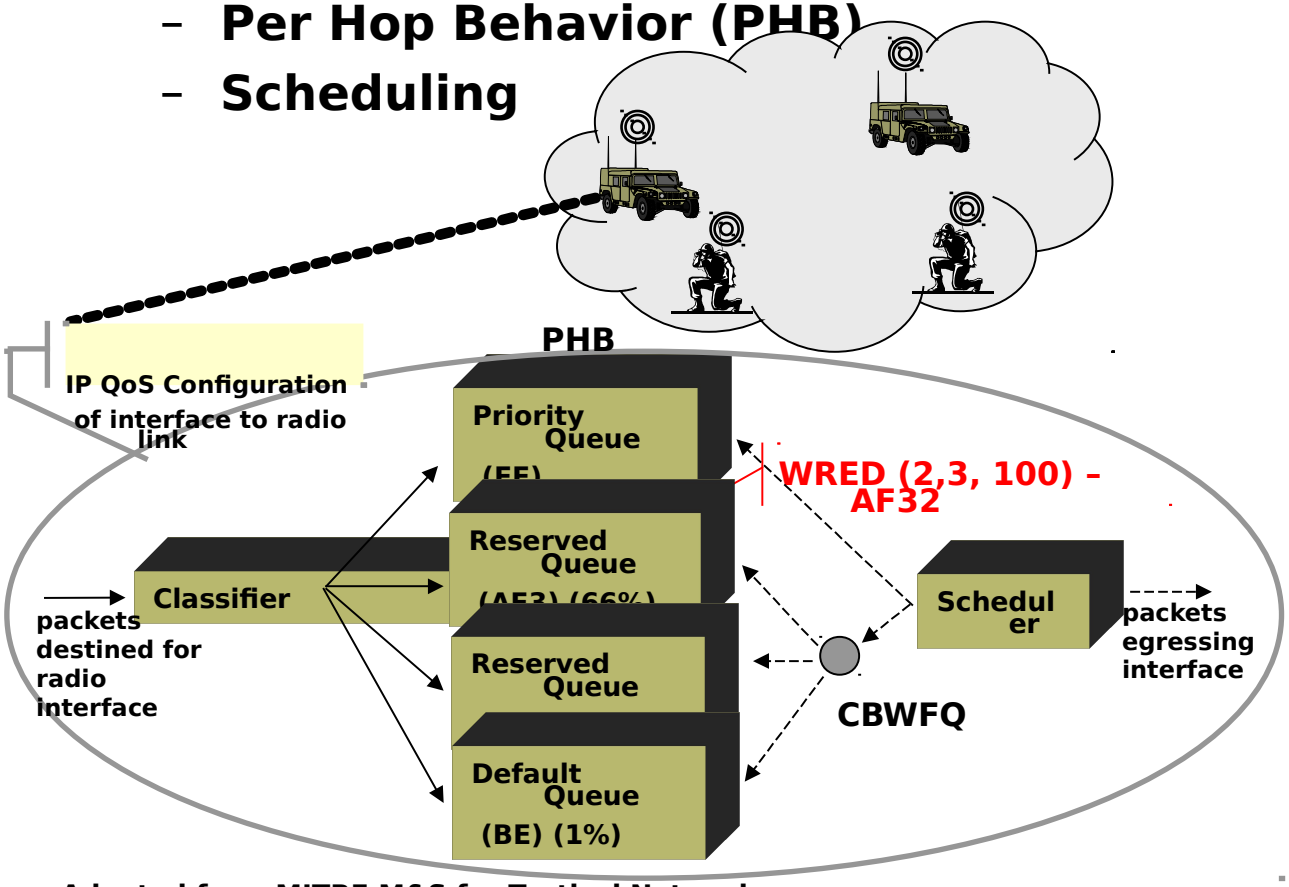
- **Use Differentiated Services (DiffServ) at each radio transmit interface. Classify VoIP traffic with the Expedited Forwarding (EF) PHB**
  - **Marking and classification**
  - **Per Hop Behavior (PHB)**
  - **Scheduling**



Service Class	DSCP (base 8)	PHB
Voice	56	EF
Streaming Video	**34**, 32	AF4
Interactive Transfer	22	AF2
Best Effort	00	BE

Source: Adapted from MITRE M&S for Tactical Networks

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Design Example : Poor TCP Performance due to Long Latency

- **Problem Description**
  - **TCP throughput can be low because of the long satellite latency**
- **What Caused the Problem**
  - **Long tactical latencies including SATCOM delays causes long ACK delays**
- **Mitigation Techniques**
  - **Send ACKs locally to the sender and reduce acknowledgment delay**

Design Example: Poor TCP Performance due to Long Latency

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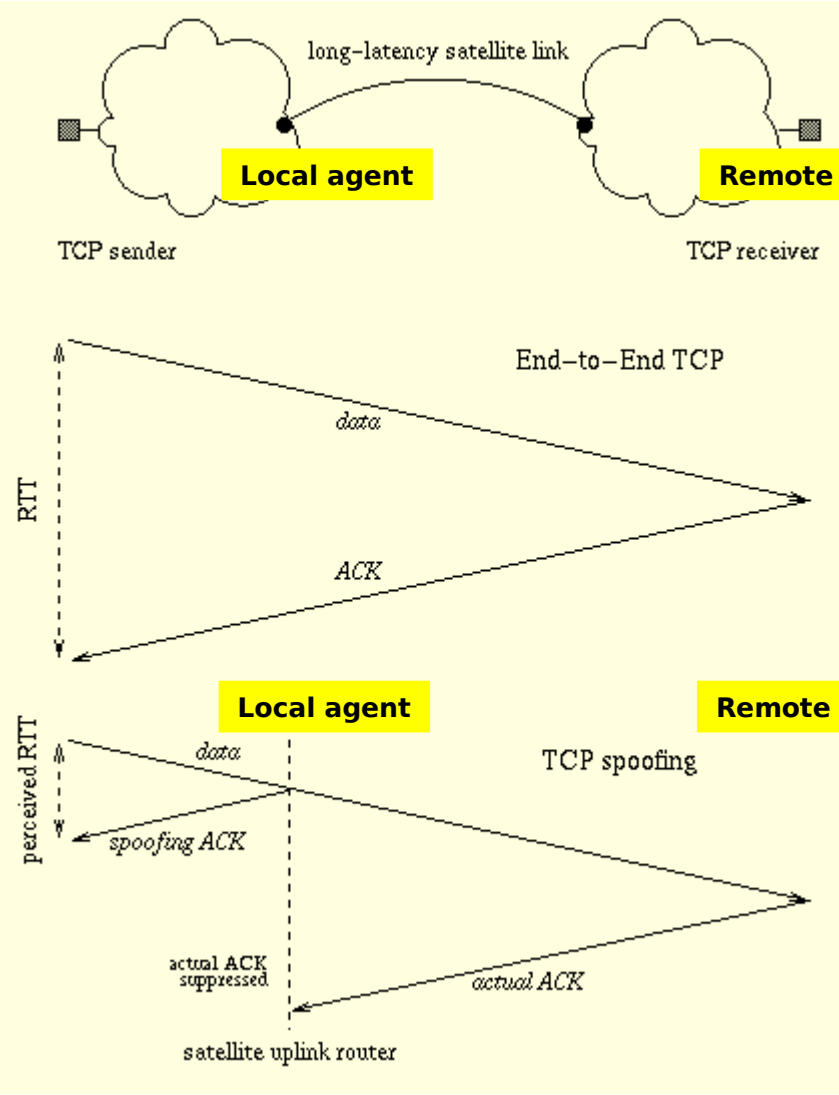
- Use TCP accelerator to return ACKs locally to the sender (RFC 3135)
- Keep the transmission links busy and avoid waiting for remote acks
- Local agent returns acks to the sender to reduce the ack delays
- Local agent communicates with remote agent using larger flow control window. Larger window accommodates longer acknowledgement delay



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Design Example: Reduce Voice Bandwidth Requirements

- **Problem Description**
  - **Voice quality is poor in low bandwidth tactical environment**
- **What Caused the Problem**
  - **Extra delay due to limited bandwidth and high error rate**
- **Mitigation Techniques**
  - **Reduce Voice over IP (VoIP) packet overhead to reduce the bandwidth usage and reduce the probability of error**
  - **Reduce VoIP packet payload by using more efficient encoders**

Design Example: Reduce Voice Bandwidth Requirements

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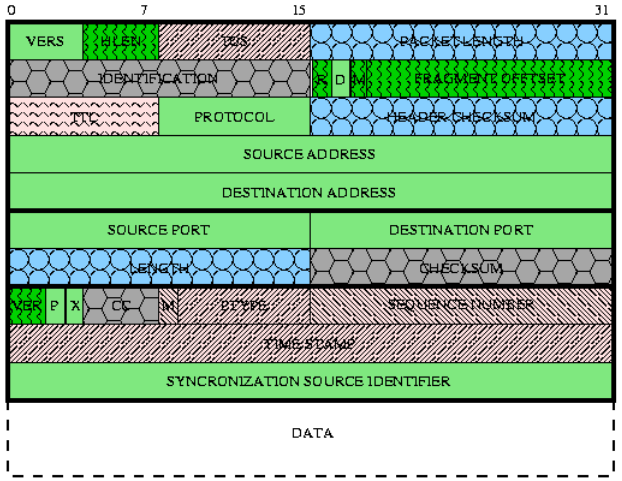
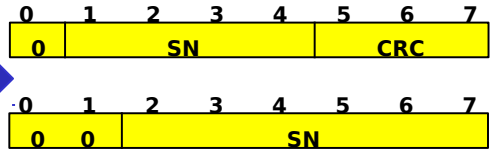
- Use Robust Header Compression (ROHC) by compressing the header from 40 bytes to 1 byte
  - Reduce the bandwidth usage
    - IP + UDP + RTP = 40 bytes
    - ROHC = 1 byte
  - Reduce the probability of header errors

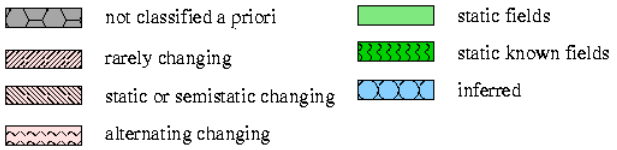
Uncompressed header (40 bytes) | **Compressed header (1 byte)** | **Compression Ratio**





Codec	IP+UDP+RTP	ROHC	Payload	Compression Ratio
G.711	40	1	160	19.5%
G.729	40	1	20	65.0%
G.723	40	1	24	60.9%

Size in bytes



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Summary of Tactical Network Design Techniques

- Many constraints can be addressed by multiple design techniques
- Many design techniques can potentially address multiple constraints
- Many commercial and tactical networks have incorporated many of the design techniques to mitigate the constraints
- Careful network design, analysis, and configuration will be required to achieve the “best” network performance

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EWSE Activities

- **Common Radio Interface to IP Layer (CRIIPL) requirement analysis**
  - **Analyzed the requirements and developed a specification for the radio to router interface**
- **Investigating the use of WiMAX in DoD tactical environment**
  - **Complete WiMAX Secure Profile**
    - **Specify a secure profile and promote interoperability between the services**
    - **Develop a design guidance**
- **Tactical QoS**
  - **Developed a tactical QoS specification using DiffServ**

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